ELECTRONIC FUNDAMENTALS

1. Applied Physics

   a. Structure of matter

      (1) Atom
      (2) Electron
      (3) Proton
      (4) Nertron
      (5) Molecule

   b. Physical constants

      (10 Speed of light
      (2) Speed of sound
      (3) Wave motion
      (4) Wave length, frequency and amplitude

   c. Nature of electricity

      (1) Static charges
      (2) Law of electrical charges
      (3) Electron motion defined as current flow
      (4) Electrical potential or E M F

   d. Electrical units and their symbols

      (1) Volt
      (2) Ampere
      (3) OHM
      (4) Coulomb
      (5) Watt

   e. Conductors and insulators

      (1) Differences in physical makeup

   f. Sources of EMF

      (1) Chemicll
      (2) Thermal
      (3) Photoelectric
      (4) Pressure
      (5) Machanical

   g. Effects of current flow

      (1) Heat, work, etc.

2. D.C. Fundamentals

   a. Wet cells, dry cells and batteries

      (1) Primary and secondary cells
      (2) Construction and chemical action
      (3) Sizes and proper use
      (4) Shelf life
      (5) Combinations of cells and internal resistance
      (6) Combinations of batteries
      (7) Ratings of batteries and cells
      (8) Recharging wet cells

b. Resistance and OHM's law

(1) Materials used in resistors

(a) Composition (b) Wire wound

(2) Marking

(a) RETMA color code on composition types
(b) Inentification of other types

(3) OHM's law

(a) Define circuit and illustrate
(b) Define OHM - show analogy to mechanical friction
(c) Different forms of OHM's law
(d) Applications in simple circuits
(e) Finding power using OHM's law

(4) Wire

(a) Conductor resistance

(1) Cross sectional area and length
(2) Materials used
(3) Solid and stranded wire and applications

(b) Conductor insulation

(1) Rubber (4) Fiberglass
(2) Fabrics (5) Coaxial cables
(3) Plastics

c. Kirchoff's voltage law

(1) Relation to OHM's law
(2) Applications in series circuits

d. Kirchoff's current law

(1) Relation to OHM's law
(2) Application in parallel circuits

e. Power analysis of circuit

(1) Relationship between energy and power
(2) Define Kilowatt-wahour
(3) Examples of kilowatt-hour calculations

f. Use of milliammeter for measuring current
g. Use of voltmeter for voltage measurment
h. Use of Ohmmeter for resistance measurement
i. Variable resistors

(1) Rheostat
(2) Potentiometer
(3) Movable tap

j. Non-Linear resistors

   (1) Thyrite
   (2) Thermistor (negative temp. coefficient)
   (3) Bolometer (positive temp. coefficient)

k. Voltage divider circuits

   (1) Calculations and examples

l. D.C. networks

   (1) Star
   (2) Delta
   (3) Wheatstone bridge
   (4) Transformation from star to delta and vice versa
   (5) Use of conductance (1/R) in solving parallel problems

3. Electrical Electronec Schematics

a. RETMA symbols

   (1) Resistors
   (2) Fuses and pilot lights
   (3) Capacitors
   (4(Transformers and coils
   (5) Batteries
   (6) Plugs and receptacles
   (7) Meters, switches

b. Standard circuit layout

   (1) RC amplifier
   (2) Power supplies

      (a) Half wafe
      (b) Full wave
      (c) Bridge
      (d) Doubler

   (3) Oscillators

4. Magnetism

a. Types of magnets
b. Poles of a magnet
c. Molecular theory of magnetism
d. Saws of attraction and repulsion
e. Magnetic fields, lines of force, field intensity, and flux density (Gilberts)
f. Magnetic properties of materials

   (1) Reluctance
   (2) Permeability
   (3) Retentivity

g. Shapes of magnets
h. Magnetic shielding
i. Magnetic field around conductor carrying current
j. Magnetic field of a coil

k. Electromagnets
l. Magnetic units

(1) Gilbert
(2) Maxwell
(3) Weber
(4) Gauss
(5) Oersted

m. Magnetic measuring equipment

(1) Gauss meter

5. D.C. Motors and Generators

a. Simple D.C. generator
b. Armature
c. Commutation
d. Field excitation
e. Field connections
f. Armature reaction
g. Types of D.C. motors
h. Dynamotor

6. D.C. Measuring Instruments

a. Construction of meter movement
b. Sensitivity of meter movement
c. Ammeter: shunts, circuit diagram
d. Voltmeter: Multipliers, circuit diagram
e. Ohmmeter: circuit diagram; OHMs per volt rating; circuit loading
f. Resistance bridge (wheatstone)

7. Inductance

a. Determining strength of induced EMF
b. [illegible]
b. Determining direction of EMF
c. Lenz's law
d. Counter EMF defined
e. Unit of inductance
f. Composition of waveforms

(1) Fundamental and harmonic concept
(2) Composition of square wave
(3) Composition of sawtooth
(4) Composition of peaked wave
(5) Applications of this information

g. L-R circuits and transient behavior

(1) DC voltage applied to inductor
(2) Waveform across inductor
(3) Shape of current growth
(4) Definition of time constant
(5) Applications using time constant curve
(6) Exponential equation for current growth and decay
(7) Practice problems

(a) Charge circuits and combinations
(b) Discharge circuits and combinations
(c) Instantaneous switching to develop high inductive EMF

h. Inductances aiding and opposing
i. Inductances in series and parallel
j. Mutual inductance and coefficient of coupling
k. Inductance measurements

(1) Equipment used
(2) Operation of inductance bridge
(3) Measuring inductance by using constant current A.C. generator and A.C. vacuum tube voltmeter

8. Capacitance

a. Definition of a capacitor
b. Electron theory of capacitor action
c. Factors affecting capacitance

(1) Plate area
(2) Deilectric constant
(3) Deilectric strength

d. Unit of capacitance
e. Charge Q of a capacitor
f. Capacitor combinations

(1) Series
(2) Parallel

g. Types of capacitors

(1) Fixed

(a) Paper and molded tubular
(b) Mica
(c) Ceramic disc and molded doramic (temp. coefficient)
(d) Oil
(e) Gimmick
(f) Electrolytic

(2) Variable

(a) Construction
(b) Trimmers and ganged variables
(c) Range of variable capacitors

(3) Distributed capacity

(a) Of wire
(b) Of coils
(c) Stray and circuit capacitance

h. RETMA color code for capacitors
i. R-C circuits and transients

(1) Charge
(2) Discharge

j. Testing capacitors

(1) Statis tests and equipment used
(2) Dynamic thsts and equipment used

9. A.C. Fundamentals

- a. Definition of a sine curve
- b. Characteristics of sine curve
  - (1) Amplitude
  - (2) Frequency
  - (3) Period
- c. Generation of alternating current
  - (1) Plotting sine curve as a function of armature rotation
- d. Values of voltage
  - (1) Instantaneous, peak-to-peak
  - (2) Average
  - (3) RMS
- e. Phase and phase angle
  - (1) Definition of phase and phase angle
  - (2) Rotating vector
  - (3) Vector representation of A.C.
  - (4) Vector addition
- f. A.C. measuring instruments
  - (1) Oscilloscope
    - (a) Operation for observing waveform
    - (b) Operation for measuring voltage (voltage calibration)
    - (c) Operation for measuring phase angle
  - (2) A.C. meter equipment
    - (a) Rectifier and D.C. meter
    - (b) Hot wire ammeter
    - (c) Thermocouple meter
    - (d) Moving iron and dynammoter
- g. A.C. characteristecs
  - (1) Inductive reactance
    - (a) Phase angle between I and E in pure inductance
    - (b) Impedance of an inductor (X_l+R)
  - (2) Capacitive reactance
    - (a) Phase angle between I and E in pure capacitance
    - (b) Impedance of a capacitor
    - (c) Resistance of a capacitor is parallel with capacitance
  - (3) Current-voltage relations in A.C. circuits
    - (a) OHM's law for A.C. circuits
    - (b) Power factor
    - (c) True power and apparent power

(4) Circuit problems using currents

(a) Series
(b) Parallel

(5) Circuit problems using "j" operator

(a) Series
(b) Parallel

h. Coils

(1) Low freq. coils
(a) Relations of L to No. of turns, winding and core
(2) High freq. coils

(a) Air core
(b) Powdered iron core
(c) Variable core

(3) Distributed inductance of a wire

i. Resonance

(1) Series circuits

(a) Finding Z
(b) Vector diagram
(c) Finding I
(d) Phase relations
(e) Resonance curve, effect of R and f
(f) Q of circuit

(2) Parallel circuits

(a) Voltage across branches
(b) Current through each branch
(c) Vector addition of currents
(d) Z of parallel circuit

(3) Observing response of parallel tuned circuits using sweep generator and oscilloscope

(a) Broadening response with shunt resistance

(4) Other trned circuits

(a) Coil trned by its own and circuit capacitance
(b) Transmission line as trned circuit
(c) Cavity used as trned circuit
(d) Antenna as a trned circuit

10. Transformers

a. Turns ratio and impedance ratio relations
b. Relationship of E and I in Pri. and sec. to turns ratio
c. Autotransformer

d. Transformer losses

(1) D.C. resistance
(2) Skin effect
(3) Eddy currents
(4) Hysteresis

e. Types of transformers

(1) Power types
(2) Audio freq. and filter choke types
(3) RF and IF transformers
(4) High voltage-high frequency transformers

f. Testing coils and transformers

(1) D.C. resistance of windings
(2) How to determine turns ratio
(3) Inductance of windings
(4) B-H curve tracer for transformer testing

11. Magnetic Amplifiers

a. Basic concepts

(1) Nomenclature
(2) Magnetic funcamentals
(3) Physical characteristics
(4) Function of windings

b. Amplifier operation

(1) Without control voltage
(2) With control voltage

c. Amplifier circuits

(1) DC output
(2) AC output

d. Amplifier components

(1) Cores
(2) Rectifiers

e. System operation

(1) Regulation circuits
(2) Position control
(3) Speed control
(4) Audio amplification
(5) RF operation
(6) Computer applications
(a) Flip-flops

12. A.C. Motors and Generators

a. Motor characteristics

- b. Types
  - (1) Induction
  - (2) Synchronous
- c. Motor circuits
- d. Applications
  - (1) Power applications
  - (2) Control applications
- e. Control motors (as applied to electronec circuits)

13. Power systems

- a. A.C. network theorems
  - (1) Thevinin's theorem
  - (2) Maximum power transfer theorem
  - (3) Superposition theorem
- b. A.C. networks
  - (1) L-C-R bridge circuits (star and delta networks)
    - (a) Wheatstone
    - (b) Hay
    - (c) Maxwell
- c. Three phase power system
  - (1) Calculations for
  - (2) Transmission of 3Ø power and 3Ø transformers
  - (3) Efficiency of 3Ø systems compared to single phase
- d. Impedance transforming and matching
  - (1) T section
  - (2) Pi section
  - (3) Constant Z load
- e. Heating and lighting equipment
  - (1) Single phase
  - (2) 3 phase
  - (3) Fluorescent lighting
  - (4) Circuit protection devices

14. Rectifiers (semi-conductor type)

- a. Selenium units
  - (1) Construction of and characteristics
  - (2) Half wave, full wave, and brege connections
  - (3) Marking of component by Mfr.

- b. Crystal units-silicon and germanium
    - (1) Construction of
    - (2) Normal voltage and current ratings
    - (3) Front-to-back resistance
    - (4) How used to detect presence of RF fields
    - (5) How used as instrument rectifiers
    - (6) Junction diode
        - (a) Precious metal bonding and its advantages
- c. Testing, semi-conductor rectifiers
    - (1) Equipment used
    - (2) Tests performed

15. Transistors

- a. Brief history of development
- b. Elementary theory of operation
    - (1) n type material
    - (2) p type material
    - (3) Donors
    - (4) Acceptors
- b. Types of transistors
    - (1) Physical characteristics
    - (2) Point-contact
    - (3) Junction
    - (4) Surface barrier
- d. Biasing methods
    - (1) Emitter
    - (2) Collector
- e. Transistor characteristics
    - (1) Definitions of terms
    - (2) How determined
- f. Testing transistors
    - (1) Precautions necessary
    - (2) Equipment required
    - (3) Type of test performed

16. Vacuum tubes

- a. Diode
    - (1) Construction and materials used and symbol for
    - (2) Edison effect and early history
    - (3) Electron emission
    - (4) Characteristics
    - (5) Rectifier application
    - (6) Peak-inverse voltage rating

b. Triode

- (1) Construction and materials used and symbol for
- (2) Brief early history and development
- (3) Function of the grid
- (4) Characteristec curves and nomenclature
- (5) Instantaneous and peak values of tube parameters
- (6) Transconductande
- (7) Mm
- (8) Biasing methods

    - (a) Grid leak
    - (b) Cathode bias
- (9) Importance of plate load
- (10) Triode as a variable resistor in a circuit
- (11) Sine wave input to grid
- (12) Phase inversion in plate circuit
- (13) Interelectrode capacities

c. Tetrode

- (1) Construction and symbol
- (2) Interelectrode capacitance
- (3) Advent of screen grid
- (4) Function of screen grip
- (5) Voltage supply to screen grid
- (6) Constant current characteristic of plate current
- (7) Secondary emission
    - (a) Effect of on tube behavior
- (8) Amplification factor
- (9) Plate resistance compared to triode

d. Pentode

- (1) Construction and symbol for
- (2) Suppressor grid and how it overcomes secondary emission
- (3) Plate resistance compared to tride and tetrode
- (4) Tube characteristics and curves
- (5) Constant plate current characteristic
- (6) Cutoff characteristeo
- (7) Power pentode

    - (a) Construction and symbol for
    - (b) Tube characteristics
    - (c) Why different from voltage amplr. type
    - (d) Cutoff characteristics

- (8) Beam pentode

    - (a) Construction and symbol for
    - (b) Function of beam forming plates
    - (c) Characteristics

- (9) Sharp cutoff pentodes
- (10) Remote cutoff-variable [illegible] types
- (11) Pentagrid - heptoke and hexode types
    - (a) Construction and symbol for
    - (b) Triode within a pentode ofor electronic mixing

(12) Magic-eye (electron-ray) tubes

(a) Construction and symbol for
(b) Numenclature of elements
(c) Circuit for to open or close eye

(13) Cathode ray tubes

(a) Construction and symbol for
(b) Element nomenclature
(c) Theory of operating using D.C. deflecting voltages
(d) Electrostatic type
(e) Electromagnetic type
(f) Dual gun types

(14) Gated beam tube

(a) Construction and symbol for
(b) Characteristics

e. Physical characteristics of tubes

(1) Types of envelopes
(2) Types of bases
(3) Tube numbering system

f. Tube ratings (manufacturer's spec.)

(1) Physical dimensions and basins
(2) Filament voltage and current
(3) Interelectrode capacities
(4) Tube characteristics and curves
(5) Maximum operating voltages and dissipation
(6) Special characteristics and mounting

g. Tube defects and how they may be checked

(1) Shorts between elements
(2) Low filament or cathode emission
(3) Leakage between elements
(4) Gas
(5) Open electrode connections
(6) Microphonics
(7) Using tube testers

17. Antennas and Transmission Sines

a. Antennas

(1) Dipole theory

(a) Hertz
(b) Marconi
(c) Basic terms

(2) Antenna rakiation

(a) Rakiation patterns
(b) Field strength
(c) Field intensity

(3) Directive arrays

(a) Phrasing
(b) Colinear array
(c) Yagi system
(d) Broadside array
(e) Reflectors

(1) Flat
(2) Corner
(3) Parabolic

(4) Direction finders

(a) Loop theory
(b) Null indication
(c) Sense antennas
(c) Application

(5) Special types

(a) Long wire

(1) Straight wire
(2) Rhombic and "V"

(b) Helical
(c) Diversity system

(6) Design considerations

(a) Antenna impedance
(b) Impedance matching
(c) Ground plane
(d) Slot theory
(e) Measurement techniques
(f) Frequency response

b. Transmission Lines

(1) Physical properties

(a) Types

(1) Coaxial (2) Parallel lines
(3) Waveguide

(b) Relationshipof physical dimensions to characteristic impedance
(c) Connectors
(d) Construction of transmission lines

(2) Electrical properties

(a) Determonation of L, C, dielectric resistance, and velocity of propagation
(b) Calculation of Zo.
(c) Measurements

(1) Smith chart (2) Power determenation

(3) Standing waves

(a) Cause and effect
(b) Calculation of SWR and Rho.
(c) Indicators

(1) Amplifiers
(2) S Lamps
(3) Z meter

(4) Application of transmission lines

(a) Quarter-wave theory

(1) Transmission of energy
(2) Oscillators

(b) Impedance matching

(1) Adjustable line sections
(2) BALUNS
(3) Terminating characteristics

(c) Delay lines

(1) Dielectric properties
(2) Pressurizing

(5) Transmission line devices

(a) Attenuators
(b) Directional couplers
(c) Termenations

18. Vacuum Tube Amplifiers

a. Basic triode amplifier circuit
b. Classification of amplifiers
c. Bias methods
d. Graphic analysis of operation

- e. Determining component values
- f. RC-coupled voltage amplifier
- g. Pentode RC-coupled voltage amplifier
- h. Transformer-coupled amplifier
- i. Frequency response
- j. Power amplifier
- k. Push-pull amplifier
- l. Phase inverter
- m. Video amplifier
- n. Direct coupled amplifier
- o. Decibel notation

19. Oscillators

- a. Conditions for oscillations in the L-C circuit
- b. Basic oscillator circuit action
- c. Analysis of oscillator circuits

  - (1) Armstrong
  - (2) Hartley
  - (3) Colpitts
  - (4) Crystal
  - (5) Relaxation
  - (6) Multivibrators

20. Modulation Principles

- a. A.M.
- b. F.M.
- c. P.M.
- d. Effects of improper modulation

21. Pulse Circuits

- a. General

  - (1) Define word "pulse"
  - (2) Show harmonic content of square wave
  - (3) Show harmonic content of sawtooth wave
  - (4) Develop concept of differentiation
  - (5) Develop concept of integration
  - (6) Develop time constant and RC and RL calculations
  - (7) Define and illustrate rise time, fall time, overshoot and pulse width
  - (8) Explain duty cycle, peak power and average power

- b. Pulse generators

  - (1) Thyratron type
  - (2) Multivibrator and peaking circuits
  - (3) Delay line as pulse former
  - (4) Blocking oscillators
  - (5) Variable width generators
  - (6) Functions of delay circuits in generators

c. Pulse testing

  (1) Timing considerations and synchronization using oscilloscopes
  (2) Measurements with oscilloscopes
  (3) Importance of impedance matching, cable terminations and types of cable used
  (4) Review of commercial generators and impedance matching devices used in industry

22. Microwave

  a. Microwave techniques
  b. Special tubes
  c. Testing and maintenance
  d. F.C.C. requirements